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SURVEY REPORT,

BRAZOS RIVER WATERSHED
TEXAS

PROGRAM FOR RUNOFF AND WATERFLOW RETARDATION
AND SOIL EROSION PREVENTION

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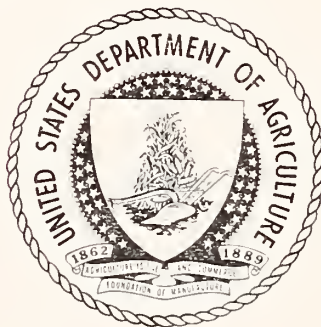
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January 1951

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Texas

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41,997 - m
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26,576

26,988,360

15.2

Estimated participation 100

69,084,000

30,403,000

9,578,000

109,065,000

Operating and Maintenance Cost Estimated

7.500

9,544,500

(Farmer 9,355,000

189,500

9,552,000

5,690,000

LIT.

902,773

3,597,352

Strat.

2,594,060

25,342,797

C. 100.520

31,035,000

7.7

25,812,979

1,175,381

42.4

11,204,316

acres: Part

42.1 12,368,117

Postponed Woodland 7.2

1,402,631

acres: Miss

45.1 336,918

crop & Post.

7

10,304,000

Non Agric.

372,000

Total

7,586,000

"sub Plant.

421,000

349,000

"water Trans.

39,000

1,49,000

Total

14,550,000

Measures	Federal \$	Non Fed. \$	Total \$
Measures	\$	\$	\$
Measures	\$	\$	\$

11,204,316

1,402,631

1,402,631

1,402,631

1,402,631

7
Total Acres of _____
Acres Under Dist. _____
Total cost for "A" measures = \$ _____
Total cost _____ on _____ acres Farm and woodland
_____ per acre and \$ _____ for each acre in area.
Total cost \$ _____ Fed.; \$ _____ Non Fed. \$ _____
Total Fed. \$ _____ or _____ % of Fed. Exp.
_____ remain for Fed. Contribution = _____ % of Fed. installation
costs and _____ % of total installation costs.
Total "B" measures \$ _____ Est. annual F.C. Benefit \$ _____
Total "C" measures \$ _____ Est. Annual Conserv. Benefit \$ _____
Other programs in the area, Army Eng. State Govt., Levee or Drainage Dist.

Other Comment

1,000
3,484,867

(1)

Measure

Terraces
Field Diversions
Cover Crops
Farm + Group Water
Gully Stabilization
Estb. of New Grasslands
Imp + Maint. Grasslands
Fire Protection
Technical Services
Educational Services
Adm. Cost for District
Floodwater Ret. Struc
Floodway + Channel Imp

Measure	Int'l Rivers	Cost per unit	Cost per unit	Cost per unit	Cost per unit	Cost per unit
Terraces	1539523	181.89	46.77	70.04	—	63.08
Field Diversions	26984	411.73	110.40	196.72	—	104.61
Cover Crops	—	5.13	1.38	2.75	—	1.00
Farm + Group Water	31066	208.85	55.95	34.70	—	118.50
Gully Stabilization	83208	1641.72	440.40	136.03	—	465.29
Estb. of New Grasslands	120215	39.56	10.61	5.54	—	23.41
Imp + Maint. Grasslands	—	6.85	1.84	1.73	—	3.29
Fire Protection	—	.30	.28		.07	
Technical Services	—					
Educational Services	—					
Adm. Cost for District	—					
Floodwater Ret. Struc	111600	76,876.43	4,266.73	57,600.00	16007.00	3,268.07
Floodway + Channel Imp	75584	34,848.62	2,052.92	50,529.40	—	14,318.56
	1997180					

Eng Shm
" Blm
woodland
add

Brazos River Watershed

348

Measure	Unit	Quantity	Total Cost to us.	Cost to Fed.	Non Federal Cost	Per Unit	Per Ac.	Per Col. 4 & Col. 8	Per Col. 1	Per Col. 2	Per Col. 3	Per Col. 4	Per Col. 5	Per Col. 6	Per Col. 7	Per Col. 8
Thruways	mile	113651	15395231	8100405	-	7294766	91036000	5640769	-	-	-	1539523	181.89	46.17	70.04	63.08
Thruway Structures	Acres	2985	897470	7214	-	312240	1229000	329530	-	-	-	26984	411.72	110.40	19.72	104.61
Cost - Thruway	Acres	193100	72425	5110	-	19210	99100	26357	-	-	-	-	5.13	1.38	2.75	1.10
Farm + Group Waterways	mile	5243	801650	180377	-	12071	1010000	293350	-	-	-	31066	205.15	55.95	34.70	118.50
Group Station	mile	2378	56744	15000	-	110404	280000	1047258	-	-	-	83208	1441.72	440.41	136.03	445.29
Relief of New Grass	Acres	233670	675376	100000	-	547140	920000	2475654	-	-	-	127010	39.56	10.61	5.54	23.41
Relief of Old Grass	Acres	3782897	18974371	611910	-	1241131	2070000	695351	-	-	-	-	6.85	1.84	1.18	3.29
Farm Road	Acres	500000	100000	10000	27000	-	15000	(112700)	7000	2500	-	-	.30	.50	-	.07
Relief of Structure	-	-	17,916	17,916	-	-	-	-	-	-	-	-	-	-	-	-
Relief of Structure	-	-	131250	131250	-	-	-	-	-	-	-	-	-	-	-	-
Cost for Relief of Structure	-	-	97520	97520	-	-	-	-	-	-	-	-	-	-	-	-
Relief of Structure	Each	555	4266720	2112740	100000	1813779	1000000	(2380034)	-	-	-	111600	76870.23	4,200.73	57,000.00	16007.50
Relief of Structure	mile	80.95	293000	100000	-	1159000	2000000	(161.184)	-	-	-	75584	34,805.23	2,000.92	53,000.00	17,319.56
			539105	8807001	9377911	3000003	2000000	17028720	7000	2500	1997180					
								(19655,44)								

Eng. Sur. 2368036
 " " 166184
 roadwork 11250
 add 325835
 17367220
 6252459

Eng. Sur. 1890000
 " " 25,250,000
 Eng. Sur. 24,800,000
 69,983,574

Names

Brayos
Waterwheel

Harmer	55	78
Castro	35	
Bailey	100	
Lamb	100	
Hale	90	
Cockson	45	
Hockley	80	
Lewis	8	
Garry	5	
Tubbock	100	
Lynn	80	
Corby	100	
Garga	100	
Dickens	40	
Kent	100	
Scaverty	40	
King	40	
Stonewall	100	
Fisher	100	
Nolan	50	
Taylor	60	
Jones	100	
Haskell	100	
Kenny	50	

<u>Trigas</u>	Baylor	50%
	Throckmorton	100
	Shackelford	100
	Callahan	55%
	Young	90
	Stephens	100
	Eastland	95
	Jack	30
	Paley	100
	Crath	100
	Comanche	100
	Parker	45
	Wood	100
	Johnson	50
	Somervell	100
	Hill	70
	Bozque	100
	Hamilton	100
	Mills	30
	Lampasas	70
	Coryell	100
	McClennan	100
	Limestone	40
	Houston	10
	Halls	100

Texas

Bell	100
Burnet	50
Williamson	100
Milam	100
Robertson	100
Leon	25
Madison	10
Bray	100
Burleson	100
Lee	90
Bastrop	5
Washington	100
Austin	70
Grimes	50
Waller	80
Hort Bend	70
Brazoria	70
Galveston	10

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UNITED STATES DEPARTMENT OF AGRICULTURE

3
Survey Report

BRAZOS RIVER AND TRIBUTARIES, TEXAS

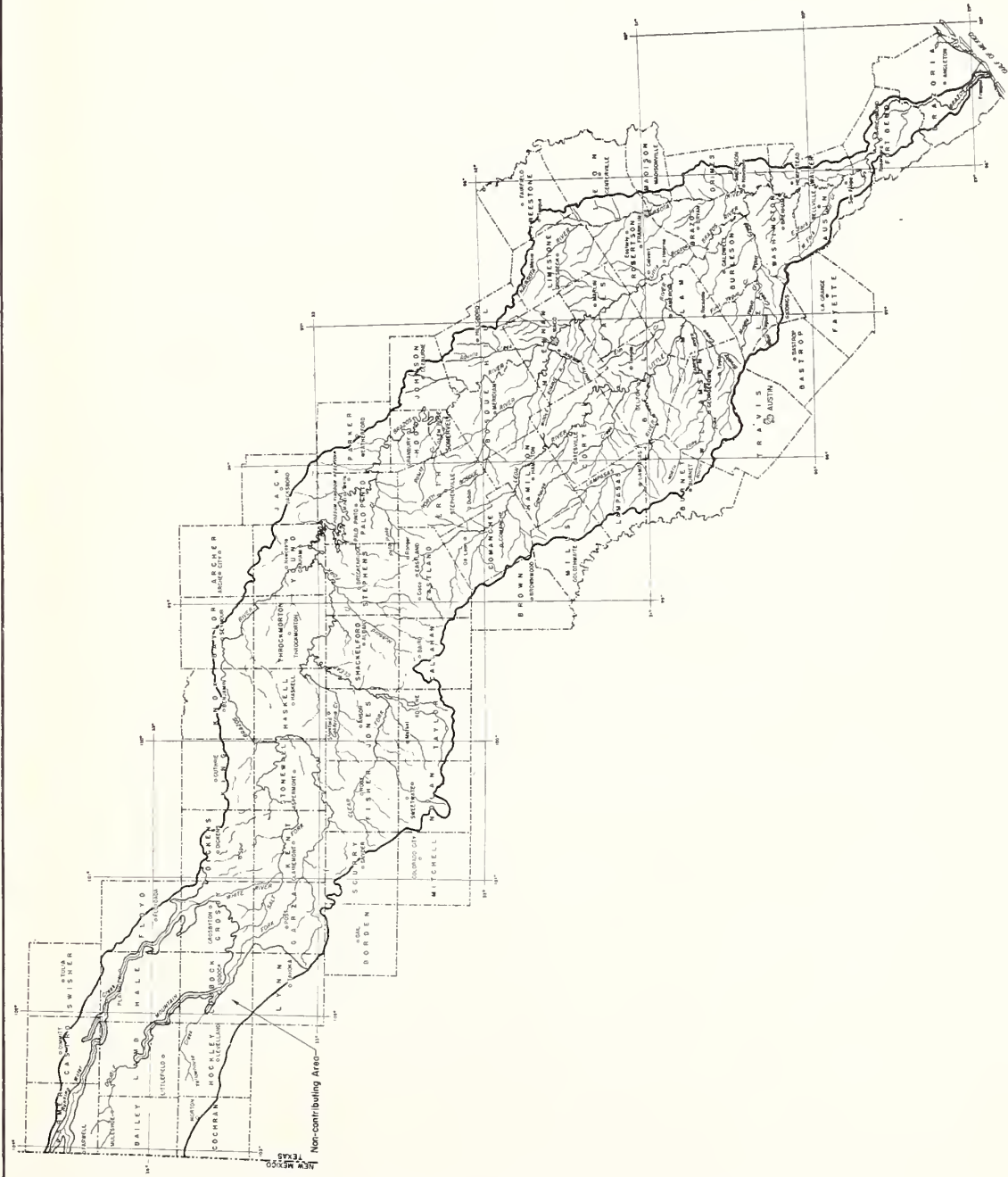
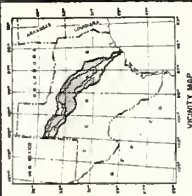
Program for Runoff and Waterflow Retardation and
Soil Erosion Prevention

Pursuant to the Act approved June 22, 1936 (49 Stat. 1570),
as amended and supplemented by the Act approved
August 28, 1937 (50 Stat. 876)

50
January 1951

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SCALE OF MILES
0 10 20 30 40 50 60 70 80 90 100

Distances computed from U.S. Department of Agriculture
Brazos River Ward U.S.G. 2. Date of Texas

LOCATION MAP
BRAZOS RIVER WATERSHED - TEXAS
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
REGION 4
H. H. BENNETT - CHIEF
CONSERVATION LOGS P. MERRILL
COMPILED BY
DATE

INTRODUCTION

Authority. -- This survey report is submitted under the provisions of the Act approved June 22, 1936 (49 Stat. 1570), as amended and supplemented by the act approved August 28, 1937 (50 Stat. 876).

Purpose and Scope of Report. -- The purpose of this report is to outline a program of runoff and waterflow retardation and soil-erosion prevention for the watershed of the Brazos River in Texas, and to present recommendations for installing and maintaining the program, together with an analysis of its cost and benefit. The area considered contains 41,997 square miles.

RECOMMENDATIONS

It is recommended that a program of runoff and waterflow retardation and soil-erosion prevention be installed during a 15-year period in the Brazos River Watershed in Texas at an estimated cost of \$69,084,000 to the Federal Government, at an estimated cost of \$9,578,000 to other public agencies, and at an estimated cost of \$30,403,000 or its equivalent 1/ to local interests, making an estimated total cost of \$109,065,000 for the installation of the recommended program.

Local interests are expected to operate and maintain the recommended program, after it has been fully installed, at an estimated annual cost of \$9,552,000 or its equivalent. Of this amount, it is expected that \$9,355,000 or its equivalent will be expended by land owners and operators for maintaining land treatment measures and for the increased cost of operating a more profitable system of conservation farming, and that \$189,500 will be expended by a local agency or agencies acceptable to the Secretary of Agriculture for operating and maintaining those installations which are not considered a part of farm and ranch operations. It is expected that the Federal Government will expend \$7,500 for operating and maintaining a system of fire protection.

The program herein recommended includes the intensification, acceleration, and adaptation of certain activities under current programs of the Department of Agriculture, and additional measures not now regularly carried out in such program, all of which are necessary to complete a balanced runoff and waterflow retardation and soil-erosion control program for the watershed. It is recommended that the Secretary of Agriculture be authorized to carry out this program. The

1/ Labor, materials, equipment, land easements, rights-of-way, and other contributions in lieu of cash payments.

extent to which the work recommended in this program is to be carried out under authority of the Flood Control Act as requested herein or under other authorities will be considered by the Secretary in requesting appropriations for the conduct of the recommended program. Although the current activities of the Department primarily related to the Flood Control Act are not included in the program herein specifically recommended, this program is based on the continuation of such current activities at least at their present level. The extent to which the measures in the recommended program may be carried out by an increase in the current programs of the Department will be taken into account in requests for the appropriation of funds to carry out the recommended program.

and independent
The interdependent measures which will accomplish the desired objectives of reducing floodwater and sediment damage and conserving soil and water resources are as follows: construction of terraces on sloping cultivated land, construction of field diversions, application of cover crops and other cropland conservation measures on cultivated land, construction and vegetation of farm and group waterways, stabilization of gullies, establishment of new grassland, improvement and management of existing grassland, construction of floodwater retarding structures and floodway and channel improvements.

and direct work
Technical services₁ will be made available for planning and applying the necessary land use adjustments, for planning and applying land treatment measures on farm and ranch lands and for integrating the measures included in the recommended program. Educational assistance will be provided to facilitate the installation of the recommended program.

The Secretary of Agriculture may construct such buildings and other improvements as are needed to carry out the measures included in the recommended program.

The Secretary of Agriculture may make such modifications or substitutions of the measures described in this report as may be deemed advisable on account of changed physical or economic conditions or improved techniques, whenever he determines that such action will be in furtherance of the objectives of the recommended program.

The authority of the Secretary of Agriculture to prosecute the recommended program shall be supplemental to all other authority vested in him, and nothing in this report shall be construed to limit the exercise of powers heretofore or hereafter conferred on him by law to carry out any of the measures described herein or any other measures that are similar or related to the measures described herein.

It is estimated that the recommended program will yield an average annual flood control benefit of \$5,690,000. 1/ In addition to this flood control benefit, an estimated average annual benefit of \$25,345,000 1/ from conservation farming and ranching will accrue to landowners and operators in the watershed.

The ratio of the estimated average annual benefit to the estimated average annual value of the total cost of the recommended program is 2.28 to 1. 2/

It is anticipated that the recommended measures will be installed under cooperative arrangements with soil conservation districts, State and local governments, or other agencies acceptable to the Secretary of Agriculture.

DESCRIPTION OF THE WATERSHED

The Brazos River in Texas flows into the gulf of Mexico near Freeport, about 640 miles southeast of its source in the High Plains of New Mexico. In Texas the watershed has an area of 41,997 square miles. The maximum width of the watershed is about 120 miles.

The Brazos River is formed by the junction of the Salt Fork and the Double Mountain Fork near Aspermont. Both streams have their source in the depression ponds of the High Plains and are relatively small as they flow down into the Rolling Red Plains. The Brazos River is joined by the Clear Fork, Palo Pinto and Paluxy Creeks, Bosque River, Little River, Yegua Creek, Navasota River, Mill Creek and numerous minor creeks and branches as it flows toward the Gulf of Mexico.

The Brazos River Watershed is a cross-section of Texas. The river flows across nine conservation problem areas which reach across the watershed. From the featureless cultivated High Plains in the west the river enters the Rolling Red Plains where some rolling sandy clay farm lands are found on interstream divides. The largest percentage however is composed of rough shallow-soil hillsides and broken valleys bordering the deeply incised, sand-bedded streams which are dry most of the year. The river traverses a smooth, shallow-limestone, grassland ridge extending into the watershed from the south and enters the mixed sandstone, limestone, and shale ridge country of the Reddish Prairies. Here the valleys are flat, surrounded by abrupt wooded slopes used for grazing. Soils are diverse and generally of low value, being either

1/ 1949 Prices.

2/ Based on future price and cost levels assumed to prevail under an intermediate level of employment.

of heavy intractable clays or loose and sandy material. At the eastern edge of this area the river enters the dissected shallow limestone plateau of the Grand Prairie. This is a valuable and extensive grazing area with some cultivated heavy clay areas on the smooth divides and in the alluvial valleys.

As the river enters the Blackland Prairie, an area of deep black cultivated land, the main valley widens and the alluvial plain is intensively cultivated to the Coast Prairie area. Tributary valleys are wide and usually cultivated except where channels are choked with sediment, causing frequent overflows. Below the mouth of the Little River is the Forested Coastal Plains, a rolling wooded area of sandy soils and occupied by small general farms. Near Bellville the river enters the flat Coast Prairie and flows through a narrow belt of Coastal Marsh bordering the Gulf of Mexico. In the small area of Coast Prairie the soils are deep and fertile and used for rice production.

The economy of the watershed is rural. Since settlement started in the east and spread westward farming and ranching have predominated in the area. Petroleum production, coal and sulphur mining, cement manufacture, quarrying of building stones, sand and gravel stripping and ceramics are important. About 96 percent of the land area is in farms and ranches and over 50 percent of the units are owner-operated.

Approximately 42 percent of the entire watershed is in cropland, 45 percent is in open grassland, 7 percent is in pastured woodland, and 6 percent in miscellaneous uses. A large percentage of the western area is subject to prolonged droughts and severe wind and water erosion. The grassland areas are unimproved and commonly overgrazed.

From 1930 to 1940 the farm population declined 12 percent, and the trend continued during the war years of 1941-1945. In 1940 the total population was about 1,040,000, of which 68 percent was classed as rural.

Annual rainfall in the watershed ranges from about 16 inches in the extreme western area to 47 inches near the coast. About three-fourths of this rainfall occurs during or immediately preceding the growing season.

FLOOD PROBLEMS

Eleven major floods have been recorded on the main stream of the Brazos River during the period 1899-1944. The majority of these occurred during the spring growing season while only 2 occurred during the winter months. Floods on the tributaries are more numerous but usually do not cause the main river to flood.

Floods are usually caused by two types of storms: (1) general storms, and (2) thunderstorms. The general storms originate either in the Gulf of Mexico or in the Southwestern Highlands, usually cover a large portion of the watershed, and may cause major or widespread flooding of tributaries and the main stream. The thunderstorms are often characterized by intense precipitation over relatively small areas, and frequently cause severe local damage but contribute little to major floods.

Crop and pasture damage constitutes 71 percent of all floodwater and sediment damage in the watershed. The flood damages occurring on the main stream of the Brazos River below Possum Kingdom Reservoir were not evaluated except in cases where the damage was caused by the overflow of a tributary stream on the Brazos River bottom.

Damaging valley sedimentation occurs chiefly in the headwaters of the Leon River, Bosque River and Paluxy Creek. Approximately 129,000 acres of cultivated and pasture lands of the alluvial plain have been seriously damaged by sediment deposition. Certain reaches in the Little River, Brushy Creek, Tehuacana Creek, Pond Creek, Big Creek, Yegua Creek, Navasota River and Mill Creek, particularly in the upper watersheds, have suffered diminished channel capacities through sedimentation, thereby impairing drainage and increasing the frequency and severity of flooding. Scouring of the inundated farm lands by rapid flood waters has seriously damaged many acres in the larger cultivated bottomland areas in the central part of the watershed.

The annual rates of storage capacity loss by sedimentation are relatively low in most reservoirs of the watershed. Possum Kingdom is losing 1 percent and Lake Waco 2.06 percent of storage capacity annually.

The estimated annual rates of capacity loss by sedimentation in the conservation and dead storage pools of the recommended and authorized reservoirs are as follows:

Lake Waco	0.60	percent
Whitney	0.30	"
Proctor	2.90	"
Belton	0.20	"
Lampasas	0.60	"
Lanesport	2.40	"
Somerville	0.50	"
Ferguson	0.60	"

Other damages which were considered but not evaluated in monetary terms include loss of life, insecurity of property and income, disruption of public service, damage to recreation and fish and wildlife, and costs of relief and sanitation.

Table 1 lists the monetary evaluation of the average annual flood-water and sediment damage in the Brazos River Watershed.

ACTIVITIES RELATED TO FLOOD CONTROL

The Department of the Army, Corps of Engineers, has prepared a survey report 1/ of the Brazos River and its tributaries which recommends the following:

- (1) Whitney Reservoir. This reservoir is in process of construction on the Brazos River and will offer additional control of flooding on the main stream below Possum Kingdom Reservoir.
- (2) Belton Reservoir. This reservoir is being constructed on the Leon River just above the Little River main valley and will offer considerable protection to that area and to the Brazos below its confluence with the Little River.
- (3) Waco Reservoir. A reservoir is recommended which will engulf the present Lake Waco on the Bosque River. Flood damages on the Bosque below the reservoir will be nearly eliminated and damages on the Brazos River will be reduced.
- (4) Proctor Reservoir. A reservoir is recommended on the Upper Leon which will greatly reduce the flood damages in the Leon River bottomlands. Proctor Reservoir will reduce the flood control storage requirements at the Belton Reservoir and permit reallocation of the excess flood control storage at Belton to conservation uses.
- (5) Lampasas Reservoir. A reservoir on the Lampasas River above its junction with the Leon River will reduce flood damages on its lower reaches and on the Little and Brazos Rivers.

1/ Report on Survey of the Brazos River and Tributaries, Texas: Oyster Creek, Texas; Jones Creek, Texas. U.S. Engineering Office, Galveston, Texas, August 1947.

TABLE I
ESTIMATED AVERAGE ANNUAL MONETARY DAMAGE
Brazos River Watershed

Type of Damage	Average Annual Damage (1949 Prices)	
	(dollars)	
FLOODWATER DAMAGE:		
<u>Agricultural and Nonagricultural</u>		
Crops and Pasture	10,304,000	
Other Agricultural	1,586,000	
Nonagricultural	<u>372,000</u>	
Subtotal		12,262,000
 <u>Land</u>		
Floodplain Scour		349,000
 SEDIMENT DAMAGE		
Deposition of Infertile Overwash	199,000	
Sedimentation of Reservoirs	421,000	
Cost of Water Treatment	<u>39,000</u>	
Subtotal		659,000
INDIRECT DAMAGE		1,280,000
<hr/>		
TOTAL AVERAGE ANNUAL DAMAGE		14,550,000

- (6) Lanesport Reservoir. A reservoir is recommended on the San Gabriel River which will greatly reduce flood damages on a major cultivated bottomland area below the dam and reduce flooding on the Little and Brazos Rivers.
- (7) Somerville Reservoir. This reservoir is recommended on Yegua Creek and will reduce flooding on the main stream of the Brazos River below. Flood heights below the reservoir will be considerably reduced.
- (8) Ferguson Reservoir. This reservoir is recommended on the Navasota River and will reduce flooding on the lower part of the Navasota and Brazos Rivers.
- (9) Local channel improvements to reduce flood damage are authorized on Mill Creek near Bellville and in the Leon River in the City of Eastland. A channel rectification project is also recommended in the City of Lampasas and levee improvements are recommended for Burleson County Improvement District No. 1 to reduce flood Damages.

The effects of these improvements have been considered in this report. The damage and benefit evaluations were made on the assumption that each improvement was constructed and operating.

Two soil conservation demonstration projects, including nearly 180,000 acres, were established on Elm and Green Creeks in 1933 and 1935 respectively. Their purpose was to demonstrate the value of erosion control practices on farms within those areas. Conservation treatment of about 50 percent of the farmland was completed by 1940 and additional acreages have been treated since that time.

The Department of Agriculture, through its several agencies and in cooperation with State and local agencies, is currently assisting owners and operators of farm and ranch lands in the application of measures which are deemed of primary importance to the objectives of the Flood Control Act. Measures being installed on cropland include terraces, field diversions, establishment of farm and group waterways, grade stabilizing and waterflow or erosion control structures, proper crop rotations, cover crops, crop residue management, and contour farming. On grasslands or on lands being converted from cropland to grasslands the measures are grass seeding, the application of fertilizer for adequate growth and establishment of cover, proper management of grazing and the control of brush and weeds. The Department of Agriculture is expending approximately \$3,108,000 annually to assist in the application of these measures on the lands of the watershed.

The State of Texas operates through several of its departments and institutions to provide valuable conservation services to farmers, ranchers, municipalities and industries. This includes research (9

experiment stations) and the dissemination of research findings, educational activities and services. Recently the Bluebonnet Ordnance Plant at McGregor was transferred to the Texas Agricultural and Mechanical College for use in experimental work. Research on crops and livestock will be carried on within the 15,000 acre area located in the drainage area of the South Bosque River. Soil conservation districts (which include nearly 100 percent of the watershed) and other similar organizations perform valuable functions in the management of soil and water resources.

The Brazos River Conservation and Reclamation District, organized under State law, is active in the watershed. Its objective is to conserve and develop the water resources of the entire Brazos River Watershed.

RECOMMENDED PROGRAM

The recommended program of runoff and waterflow retardation and soil-erosion prevention includes the following interdependent measures:

1. Construction of approximately 115,650 miles of terraces. These will be constructed on sloping farm lands to conduct excess rainfall at non-erosive velocities to protected outlets or waterways. This measure will reduce the amount of sediment carried to streams by decreasing the length of unbroken slope. All terraced land will be cultivated parallel to the terrace.
2. Construction of approximately 2,990 miles of field diversions. These graded channels will be designed to divert runoff away from severely eroded or local high-damage areas. Their use will assist in the establishment of grassland and in the protection of cropland measures to be used for cover protection and erosion control.
3. Establishment of cover crops on approximately 193,100 acres of cropland. Cover crops will protect the soil from erosion and will increase the soil organic matter. These crops, used for green manures or as cash crops, will be grown in the normal cropping systems and will occupy approximately twenty to twenty-five percent of the cropland each year.
4. Application of cropland conservation measures as needed, either alone or in combinations. Treatment will vary from area to area depending upon physical conditions, and will be applied on about 1,852,290 acres. On land requiring some protection but not in need of terraces, contour farming will be practiced for water conservation. Improved rotations will be used to

increase the water holding capacity of the soil and improve cover conditions. Crop residue management will be practiced to retard runoff, reduce erosion and increase the rate of rainfall infiltration into the soil.

5. Shaping and stabilizing by vegetative control approximately 5,240 miles of farm and group waterways to reduce the amount of sediment and gullying resulting from the uncontrolled out-letting of terraces. Broad vegetated strips with minimum shaping will be used to spread and conserve the runoff from the terraced fields.
6. Stabilization of approximately 2,380 miles of gullies and channels, for waterflow and sediment control. Revegetation, shaping, drop structures and small earthfill dams, to reduce the uncontrolled gradient of channels, arrest head cutting and reduce the rate of discharge of runoff by natural or artificial controls will be used to control land damage and the amount of sediment resulting from erosion of the channels.
7. Establishment of new grassland on approximately 233,700 acres of cropland unsuited to continued crop use and idle cropland which has an inadequate protective cover. The areas will be seeded to adapted grass and legume mixtures, fertilized, fenced and properly managed as pasture. The grass cover will protect the soil from continued erosion and will increase infiltration of rainfall.
8. Improvement and management of approximately 3,782,900 acres of existing grassland, including reseeding with adapted grass and legume mixtures to rapidly improve the protective vegetative cover. Brushy areas in the grasslands on which competition has resulted in an inadequate protective cover will be cleared of brush, seeded and managed to insure a heavy grass cover. The use of proper systems of grazing will permit optimum forage growth, build up the vitality of the grass, and promote soil binding root growth. This will provide adequate seed for natural reseeding and provide cover to reduce runoff and protect the soil.
9. Fire protection for 500,000 acres of private woodlands in the Forested Coastal Plains to increase infiltration and the waterholding capacity of the soil and to reduce erosion and sediment production.
10. Construction of approximately 555 floodwater retarding structures. These structures, by providing temporary storage of floodwaters from approximately one-third of the watershed, will

reduce flood peak discharges in the floodplains below the structures.

11. Construction of approximately 81 miles of floodway and channel improvements on tributary streams to reduce floodwater and sediment damage. Channels which are inadequate in size have forced the retirement of high-producing floodplain land to grazing use or idleness. Floodwater retarding structures will reduce the peak flood flows, but the floodway or channel will require enlargement in order to carry releases from the structures and runoff from the uncontrolled area without flooding the entire floodplain too often for crop use.

Technical services, ^{and design work} will be made available for planning and applying the necessary land use adjustments and land treatment measures on the farms and ranches, and for integrating these measures with the other measures included in the recommended program. Educational assistance will be provided to facilitate the installation of the recommended program. Technical services, ^{design work} and educational assistance provided under this program will be directed toward furthering the specific objectives of floodwater and sediment damage reduction and will be fitted as to method and synchronization into subwatershed operations activities.

Provision will be made in selected segments of subwatersheds for the measurement of precipitation, runoff, groundwater recharge, and sediment loads of streams, to facilitate application of the recommended program.

COST OF RECOMMENDED PROGRAM

The estimated cost of installing the recommended program in the Brazos River Watershed is shown in table 2. Of this cost it is estimated that the Federal Government will expend \$69,084,000, other public agencies will expend \$9,578,000 and private interests will contribute \$30,403,000.

The recommended program will be operated and maintained at an estimated annual cost of \$9,552,000 or its equivalent to local interests. Of this amount, it is estimated that \$9,355,000 will be expended by landowners for operating and maintaining land treatment measures and for the increased cost of operating a more profitable system of farming, and that \$189,500 will be expended by a local agency or agencies acceptable to the Secretary of Agriculture for operating and maintaining floodwater retarding structures and floodway and channel improvements. It is estimated that the Federal Government will expend \$7,500 annually for operating and maintaining a system of fire protection.

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TABLE 2
ESTIMATED COST OF INSTALLING THE RECOMMENDED PROGRAM
Brazos River Watershed

Measure	Unit	Quantity	Cost (1949 Prices) (dollars)
Terraces	Miles	115,650	21,036,000
Field Diversions	Miles	2,990	1,229,000
Cover Crops	Acres	193,100	990,000
<i>Sod waterways</i> Farm and Group Waterways	Miles	5,240	1,095,000
Gully Stabilization <i>C-14</i>	Miles	2,380	3,904,000
Establishment of New Grassland	Acres	233,700	9,214,000
Improvement and Management of Existing Grassland <i>deferred grazing</i>	Acres	3,782,900	25,930,000
Fire Protection	Acres	500,000	150,000
Floodwater Retarding Structures	Each	555	42,666,000
Floodway and Channel Improvement	Miles	81	2,821,000
Total			109,065,000 ^{1/}

^{1/} Of this amount 15.6 percent is for technical services, hydrologic studies to facilitate program installation, administration of direct aids and educational assistance. Non-Federal public agencies will bear approximately one-half the cost of educational assistance and one-quarter of the cost of a system of fire protection.

BENEFITS FROM THE RECOMMENDED PROGRAM

The recommended program will reduce floodwater and sediment damages and increase crop production. It is estimated that the program will reduce floodwater damage to crops, grassland, and other agricultural property by approximately 35 percent, floodwater damage to land by approximately 36 percent, sediment damage by approximately 24 percent and indirect damage by approximately 29 percent. Other benefits will accrue from the more intensive use of floodplain lands made possible by the elimination of numerous small floods. Benefits in the form of increased crop and grassland yields will result from the installation of the land treatment portion of the program.

The full attainment of the benefit evaluated in this report is dependent upon the cooperation and support of farm owners and operators and local agencies in installing and maintaining the recommended practices and measures.

The estimated average annual monetary benefit resulting from the recommended program for the Brazos River Watershed is shown in table 3.

In addition to the monetary benefits, there will be unevaluated benefits such as reduction of loss of life and alleviation of illness, hardship and disease epidemics following flood disaster; increased food and improved shelter for wild fowl and game animals; a greater population of fish as a result of clearer streams of more even flow; and improved recreational facilities.

COMPARISON OF BENEFIT AND COST

The ratio of the estimated average annual benefit to the estimated average annual value of the total cost of the recommended program is 2.28 to 1. The ratio has been computed on the basis of future price and cost levels assumed to prevail under an intermediate level of employment.

TABLE 3

ESTIMATED AVERAGE ANNUAL MONETARY BENEFIT FROM THE RECOMMENDED PROGRAM

Brazos River Watershed

Source	Average Annual Benefit (1949 Prices) (dollars)
REDUCTION IN FLOODWATER DAMAGE	
<u>Agricultural and Nonagricultural</u>	
Crops and Pasture	3,597,000
Other Agricultural	570,000
Nonagricultural	<u>141,000</u>
Subtotal	4,308,000
<u>Land</u>	
Floodplain Scour	125,000
REDUCTION IN SEDIMENT DAMAGE	
Deposition of Infertile Overwash	51,000
Sedimentation of Reservoirs	100,000
Cost of Water Treatment	9,000
Subtotal	160,000
REDUCTION IN INDIRECT DAMAGE	373,000
INTENSIFIED USE OF FLOODPLAIN LANDS	
Increased Income from the Land	724,000
CONSERVATION BENEFIT <u>1/</u>	<u>25,345,000</u>
TOTAL AVERAGE ANNUAL BENEFIT	31,035,000

1/ The benefit which accrues to the owners and operators of the land on which the recommended program is installed.

